Emotions, Music, and Acetaminophen

Honors Undergraduate Research Thesis

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By

Rani Inderjit Bawa

The Ohio State University

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Project Advisor: Dr. Baldwin Way, Department of Psychology

Thesis Committee Members: Dr. Lisa Libby, Department of Psychology & Dr. Karen Eliot, Department of Dance

Abstract

Music is a complex combination of auditory notes that is made to elicit emotions from the listener. Indeed, when listening to pieces of music, people often like or dislike them as well as feel emotions from them. A recent study (Warrenburg, Huron, & Way, in preparation) has shown that the drug acetaminophen can alter the psychological impact of music, lowering negative as well as positive evaluations of music. To understand more about the psychological effects of acetaminophen in response to music, three investigations were undertaken. First, new analyses were performed on data from the aforementioned study of acetaminophen and music in order to identify potential psychological processes that could explain the blunted positivity and negativity ratings while taking acetaminophen. In that study, participants listened to a short clip of music, rated the positivity or negativity of it, the emotional arousal of it, the perceived familiarity of it, as well as emotions evoked by the clip of music. The new analyses conducted for this thesis revealed that acetaminophen lowered familiarity ratings of pieces of music. Second, mediation analyses were performed to probe the mechanism by which familiarity is related to acetaminophen's effects on reducing evaluations. Two possible theoretical models were identified. The mere exposure and processing fluency model suggests that familiarity mediates the relationship between acetaminophen and reduced evaluations in response to music clips. The warm glow model suggests that acetaminophen lowers evaluations, and that this lowering of evaluations leads to less perceived familiarity. The results of the mediation analyses supported both possible models. To study this effect further, we proposed a third investigation in order to probe more deeply into the familiarity component of processing, in order to understand more about how acetaminophen influences processing of auditory stimuli. This new study will test the mere exposure and processing fluency model of familiarity. This will be achieved by using a

similar procedure, but participants will be asked to rate the familiarity of stimuli on a more precise scale and asked if they are able to name the piece of music they hear. This allows us to draw connections between the depth of familiarity and the effects of acetaminophen on familiarity. We hypothesize that 1) acetaminophen will reduce familiarity, which will, in turn, lead to evaluation blunting, and 2) familiarity will also moderate the relationship between acetaminophen and evaluation blunting, such that the blunting is strongest for moderately familiar music clips. These findings will provide further novel insights into how acetaminophen is altering affective experience.

CHAPTER 1

Introduction

When the typical person feels a fever coming on or a persisting muscle ache, what do they do? Reach for a medication such as Tylenol. Indeed, 23% of Americans use acetaminophen, commonly known as Tylenol, weekly to reduce fever and pain (Kaufman et al., 2002). However, studies have shown that though acetaminophen does act as an analgesic and antipyretic, it may also be altering various other psychological phenomena, such as social pain, emotional reactions, empathy, and risk-taking behaviors (DeWall et al., 2015; DeWall et al., 2010; Durso et al., 2015; Keaveney et al., 2020; Mischkowski et al., 2016; Randles et al., 2013). The mechanism by which acetaminophen produces these psychological effects is unknown, as is the extent of the psychological effects. However, alterations to either the perception of emotional information or accessibility of emotional information from memory could be contributors to these effects. Therefore, the goal of this project is to explore these mechanisms in greater depth. The myriad of psychological effects surrounding acetaminophen, combined with the high usage rates of the medication, warrant further research in this field.

Emotional Blunting and Acetaminophen

Over the past decade, research investigating the psychological effects of acetaminophen has unveiled results showing that acetaminophen influences emotions. In 2010, DeWall and colleagues published findings showing that three weeks of daily acetaminophen administration can reduce the pain felt by social rejection and also reduce neural activation in brain regions associated with social pain. Social pain can be conceptualized as an emotional process that represents the emotions felt by hurt feelings, connecting the feeling of pain to the negative

emotions associated with it (MacDonald, 2009). Another study by this team examined the effects of acetaminophen on decision making and found that the drug reduces the pain felt when making difficult decisions (DeWall et al., 2015). Similarly, this pain connects to the negative emotions that it evokes. Building upon this, evidence was found that acetaminophen blunts evaluations to positive and negative stimuli (Durso et al., 2015). Participants who took acetaminophen also rated images as less emotionally arousing than those who took a placebo drug. In addition to acetaminophen's pain blunting and emotional blunting effects, a 2016 study showed that acetaminophen can reduce empathy (Mischkowski et al., 2016), which can be viewed as a reduction in the experience of other's emotions. While research has demonstrated the emotional blunting effects of acetaminophen, the mechanism behind these effects is unknown.

Acetaminophen and Music

Data from a previous study (Warrenburg, Huron, & Way, in preparation) investigating the role of acetaminophen on responses to music clips extends the blunting effects of acetaminophen from visual stimuli (Durso et al., 2015) to auditory stimuli. In this study, there were two blocks of music stimuli (presented in counter-balanced order). In one block, participants listened to various clips of music and rated their perception of the clips by rating their positivity or negativity. These positivity and negativity ratings will henceforth be referred to as evaluations. The other block asked participants to identify the emotions they experienced while listening to the clips of music, again in terms of positivity and negativity. Henceforth, this will be referred to as experienced emotion. This distinction was made due to the fact that there can often be a dissociation between the experience of a piece of music, which can be described as evoking a negative emotion (e.g. sadness), and the evaluation of a piece of music, which may in fact be rated as positive to listen to (Gabrielsson, 2001; Schubert, 2013, 2016).

Acetaminophen significantly reduced positive evaluations to music clips as well as reduced negativity evaluations to the music clips. However, acetaminophen did not significantly affect experienced emotion ratings. This study also included several other personality and cognitive variables that may influence acetaminophen's effects, and the one we focus on here is familiarity. Familiarity was measured because it can be an important predictor of evaluations and emotional responses to music (Schellenberg et al., 2008).

Familiarity is a broad concept, encompassing memory, processing fluency, affect, and awareness. While on the surface, familiarity is the feeling of recognizing something, the actual source behind that sense of recognition can vary greatly. Sometimes, something is recognized because it can be attributed to a specific memory. Other times, the source behind the familiarity is unclear. It is this process of familiarity, of which the source is unclear, which presents an interesting field of research into cognitive processing. The effects of acetaminophen on familiarity are unknown. Therefore, the first aim of this thesis is to conduct new analyses on familiarity in order to determine possible mechanisms that explain the blunted evaluations by acetaminophen in response to music clips.

Methods

Study Design

The study by Warrenburg, Huron, & Way (in preparation) utilized a randomized, double-blind, parallel-group, placebo-controlled design. Participants (n=244) were undergraduate students recruited through the Research Experience Program from the Department of Psychology at The Ohio State University. 123 participants were randomly assigned to the drug condition, and 121 to the placebo condition. The average age of the participants was 19.3 (range 18-44). 125

males (51%) and 107 females (44%) participated in the study, 5 participants selected “prefer not to answer”, and the remaining 7 participants left this question blank.

The study examined both evaluations and experienced emotions from music clips, natural sounds, and human speech sounds. Portions of the study pertaining to the present project will be briefly described.

Stimuli were selected from a database of emotional film music clips, curated by Eerola & Vuoskoski (2011). For the evaluations condition, these clips were 12-16 seconds in duration and covered four categories of emotions: fear (3 clips), happiness (3 clips), sadness (3 clips), and tenderness (6 clips). After listening to the music clips, participants rated the clips for positivity, negativity, familiarity, and arousal. For the experienced emotion condition, the music clips ranged from 45-59 seconds in length and covered the same four categories of emotions: fear (2 clips), happiness (2 clips), sadness (2 clips), and tenderness (2 clips). After listening to the experienced emotion music clips, participants rated the clips for positivity, negativity, and familiarity. The order of the evaluation and experienced emotion conditions were randomized across participants. Each condition began with clear instructions to focus on the evaluation of the music clip or one’s experience of the clip. Participants began these ratings one hour after taking the drug or placebo to allow the drug time to reach the brain.

Analysis Variables

The independent variable analyzed was the drug condition, acetaminophen or placebo. The dependent variable analyzed in this chapter is ratings of familiarity in response to each music clip. This was probed by asking participants:

"*How familiar are you with this audio file*?" using a 3-point Likert scale (0: not familiar, 1: somewhat familiar, 2: very familiar)

Analysis Methods

In order to examine main effect of acetaminophen, independent samples t-tests were conducted using the SPSS Version 25 statistical package.

Results

Main Effect

Analyses were conducted to examine effects of acetaminophen on familiarity across all music categories; results of interest are described below. An independent-samples t-test indicated a marginally significant effect of acetaminophen blunting familiarity across all music clips, in both the perceived evaluations and experienced emotion portions of the study (M=0.7473, SD=0.7066), as compared to the placebo condition (M = 0.9184, SD = 0.8195; t(242) = 1.745, p =0.082, d = 0.22).

Evaluations

In the evaluations portion of the study, an independent-samples t-test revealed a marginally significant effect of acetaminophen blunting familiarity (M=0.3337, SD=0.329), as compared to the placebo condition (M = 0.4122, SD = 0.383; t(235.397) = 1.715, p =0.088, d = 0.22). When this was decomposed into responses to positive and negative music clips, analyses indicated an effect of acetaminophen significantly blunting familiarity for positive music (combination of happy and tender categories; M=0.3435, SD=0.3605), as compared to the placebo condition (M = 0.4442, SD = 0.4097; t(244) = 2.039, p =0.042, d = 0.26), and a

nonsignificant effect of acetaminophen on reducing familiarity for negative music (combination of sad and fear categories; M=0.3238, SD=0.3515), as compared to the placebo condition (M = 0.3802, SD = 0.4072; t(235.777) = 1.156, p =0.249, d = 0.15).

Experienced Emotion

In the experienced emotions portion of the study, an independent-samples t-test revealed a nonsignificant effect of acetaminophen blunting familiarity (M=0.4136, SD=0.4304), as compared to the placebo condition (M = 0.5062, SD = 0.4751), t(242) = 1.596, p =0.112, d =0.20). When separated by valence, analyses indicated a marginally significant effect of acetaminophen on blunting familiarity for positive music (M=0.4350, SD=0.4581), as compared to the placebo condition (M = 0.5434, SD = 0.5201; t(242) = 1.729, p =0.085, d = 0.22). There was a nonsignificant effect of acetaminophen reducing familiarity for negative music (M=0.3923, SD=0.4550), as compared to the placebo condition (M = 0.4690, SD = 0.4890; t(242) = 1.269, p =0.206, d = 0.16).

Emotional Categories of Music

While the primary focus of these analyses was on acetaminophen's effects on positive and negative evaluations and experienced emotions to 1) all music, 2) positive music, and 3) negative music, exploratory analyses were also conducted examining effects of acetaminophen on evaluations for each of the 4 emotion categories of music. Of these individual emotion categories of music, there was only a significant reduction in familiarity by acetaminophen for tender music (M=0.3211, SD=0.3635) as compared to the placebo condition (M=0.4421, SD=0.4563; t(228.868)=2.289, p=0.023, d=0.29). The means from the other emotion categories are depicted in Figures 1 and 2.

Figure 1: Perceived Familiarity Ratings Across 4 Categories of Emotional Music Clips, Perceived Evaluations Portion of Study (Error bars denote Standard Error of the Mean).

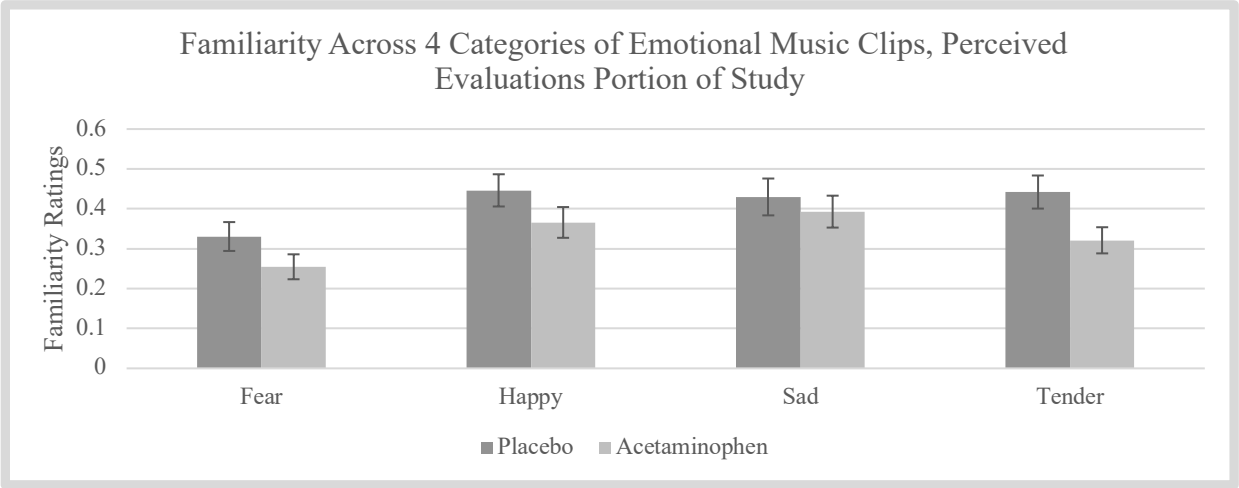
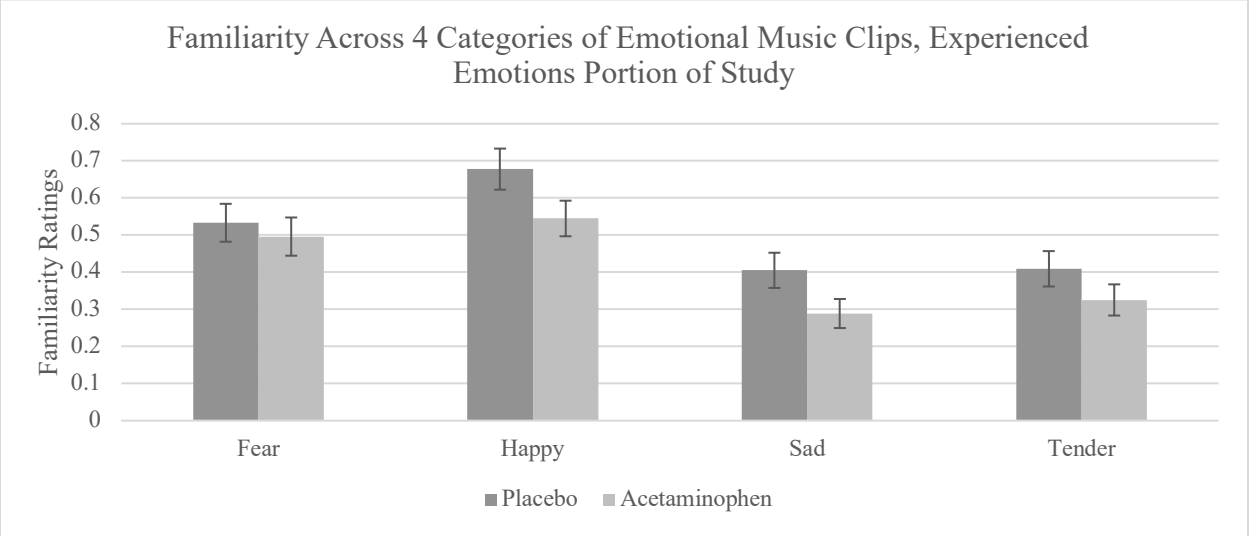


Figure 2: Perceived Familiarity Ratings Across 4 Categories of Emotional Music Clips, Experienced Emotions Portion of Study (Error bars denote Standard Error of the Mean).



It is important to note that, as demonstrated by the mean values for familiarity, familiarity ratings were on average quite low. Stated differently, because “not familiar” was coded as 0 and “somewhat familiar” was coded as 1, the average music clip was not familiar to the participant. Of the 23 music clips played for participants, only two had more than 10% of the sample rating

them as very familiar (For the Experienced Emotion Fear Music Clip 1, 13.5% rated it as very familiar and for the Experienced Emotion Happy Music Clip 2, 18.5% rated it as very familiar). Even so, familiarity was blunted by acetaminophen for all four categories of emotional music, although, as described above, only significantly for tender music in the perceived evaluations portion of the study. Of the 15 music clips played in the perceived evaluations portion of the study, acetaminophen lowered familiarity ratings for 13 of them. Of the 8 music clips played in the experienced emotion portion of the study, acetaminophen lowered familiarity ratings for all of them. The evidence presented by these analyses suggests that acetaminophen has effects on familiarity, particularly the familiarity of positive music clips whether the participant is responding with their evaluations or experienced emotions.

CHAPTER 2

The results of the analyses presented in the prior chapter raise interesting questions regarding the relationship between the effects of acetaminophen on familiarity, evaluations, and experienced emotion. While previous research has demonstrated effects of acetaminophen on evaluations and emotions, the investigation of acetaminophen's effects on familiarity presented here are novel work, to our knowledge. Following the discovery of a main effect of acetaminophen reducing familiarity to music clips, this chapter aims to further investigate this relationship and its directionality. Is there a relationship between acetaminophen's effects on familiarity and evaluations or does acetaminophen influence familiarity and evaluations independently? There is a theoretical basis for familiarity to influence evaluations, as well as for evaluations to influence familiarity. These theoretical models will be described below.

Mere Exposure Effect: Model 1

Early research in this field centered around the mere exposure effect, a phenomena coined by Robert Zajonc in 1968 (Zajonc, 1968). The mere exposure effect connects familiarity to emotion, showing that merely being exposed to a stimulus increases one's positive attitude towards it.

Why do humans prefer familiar stimuli? There are multiple theories behind the mere exposure effect (for a review, see Montoya et al., 2017). The original theory proposed by Zajonc was known as the affective model. This postulates that evolutionarily, humans fear unfamiliar stimuli. Unfamiliar stimuli pose possible danger which cannot be adequately assessed before encountering the stimulus. The affective model states that when someone is exposed to a stimulus repeatedly, the fear of an unfamiliar stimulus decreases, thus creating a positive attitude towards the previously unfamiliar, but now familiar, stimulus. Experimental manipulations show

an increase in positive affect and decrease in negative affect towards a stimulus upon repeated exposure.

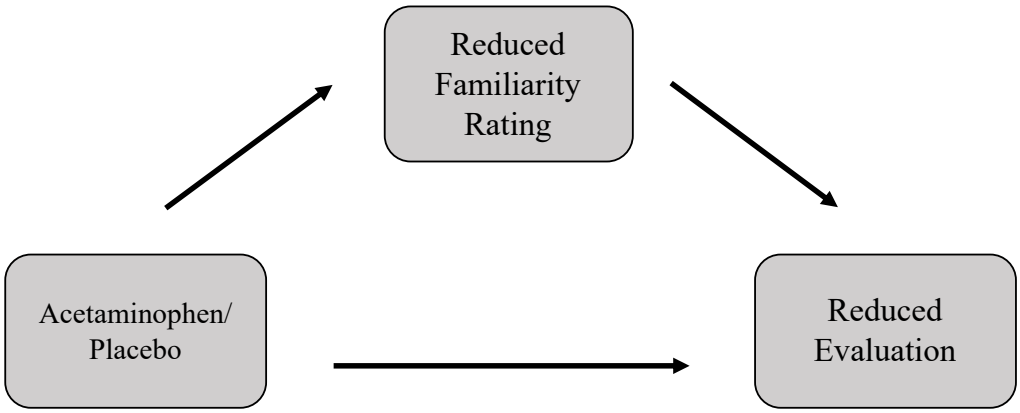
In addition, research shows that the mere exposure effect is greater when the exposure to a stimulus is subconscious, rather than conscious (Jacoby & Whitehouse, 1989). This relates to processing fluency (Reber et al., 2004), which states that if a stimulus is familiar, it is easier to process, which leads to more positive feelings. The theory is that the positivity felt due to the ease of processing is misattributed to the stimulus itself, creating a positive association with the stimulus.

Although this research explains the link between familiarity and positivity, one may wonder if the increase in processing fluency truly is the reason behind the positive affect observed. Until 1998, all studies published had connected mere exposure to processing fluency, and processing fluency to positive affect. This two-step link has been demonstrated by numerous studies, but the link between processing fluency and positive affect, without using exposure to induce processing fluency, was untested. Through two experiments, Reber, Winkielman, & Schwartz (1998) manipulated processing fluency through methods other than repeated mere exposure. They found that when processing fluency was increased, positivity also increased. This was done by varying the duration of mere exposure (ranging from 100-400 ms) as well as altering the figure-ground contrast. Figure-ground contrast is the amount that a stimulus stands out from its background. A stimulus that stands out more from the background is easier to process; this equates to a high figure-ground contrast. An example would be a black stimulus on a white background. On the other hand, a black stimulus on a dark gray background is more difficult to process and is an example of a low figure-ground contrast. The results of these two experiments confirm that processing fluency is affectively positive, regardless of the way that it

occurs. Further evidence supporting this link comes from EMG studies which show that during processing fluency, a person's facial muscles form displays of positive affect such as smiling (Winkielman & Cacioppo, 2001). This is an important finding because it uses an objective measure of positive affect (EMG recordings), rather than a subjective measure (asking a person if they like something).

This mere exposure and processing fluency model represents one of the two possible mechanisms to be tested. According to this theory, familiarity drives changes in evaluations, i.e., increased positive evaluations. Therefore, this model would propose that acetaminophen blunts familiarity, and that blunted familiarity in turn is what reduces positive evaluations.

Figure 3: Familiarity as Mediator of Drug Effects on Evaluations and Emotion Ratings (Model 1)



Warm Glow Heuristic: Model 2

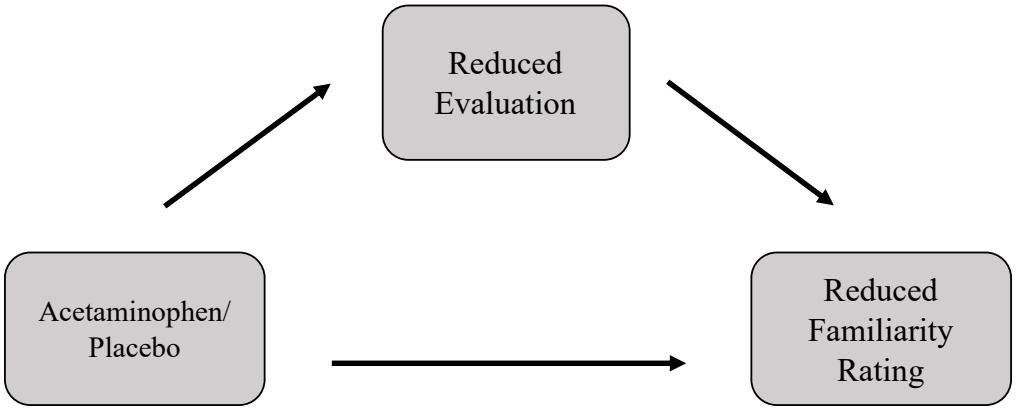
Another piece of research that could explain the direct relationship between familiarity and evaluations is the warm glow heuristic (Monin, 2003). A heuristic is a mental pattern of processing information and making decisions that can be used as a shortcut. While using a heuristic doesn't always guarantee the best outcome, heuristics are easier and faster to use and therefore preferred by humans. In general, people tend to use direct, or heuristic, processing

rather than complex, indirect processing if there is not much source knowledge available, such as having a low familiarity with a stimulus.

The warm glow heuristic states that the positive evaluation of a stimulus increases its perceived familiarity, independent of whether a person has seen the stimulus before or not. This suggests that the relationship between familiarity and evaluations is opposite: evaluations are what drive familiarity. The warm glow heuristic has been replicated in various studies (Garcia-Marques et al., 2004; Phaf & Rotteveel, 2005), bringing up the question of why this effect could have developed in humans. One possible explanation presented by Monin (2003) is the prototypicality explanation, explaining that stimuli with positive evaluations feel familiar because they resembles prototypes. For example, the prototypical image of beauty shares many characteristics with faces that are evaluated positively. Therefore, since positive faces are similar to prototypes, they will be perceived as familiar.

Another possible explanation for the warm glow heuristic is an emotion-based explanation. Because familiarity is an innately positive feeling, as explained by Zajonc in the affective model, it could be that feelings of positivity inadvertently give rise to feelings of familiarity. Research shows that positive moods can lead to more errors in identifying stimuli as having been seen before when in fact they are novel stimuli, as compared to negative moods, which lead to less erroneous identifications of stimuli as familiar ((Storbeck & Clore, 2005). Regardless of whether affect or prototypicality better explain the warm glow effect, its results are robust, warranting need to test this model alongside the mere exposure and processing fluency model. This model (depicted in Figure 4) proposes that acetaminophen blunts positive evaluations, and that blunted positivity in turn is what reduces familiarity ratings.

Figure 4: Evaluations and Emotion Ratings as Mediator of Drug Effects on Familiarity (Model 2)



These fields of research present two possible mechanisms explaining the connection between familiarity and evaluations: the mere exposure and processing fluency model, and the warm glow model. This chapter aims to test each of these models, using data from the music and acetaminophen study analyzed in Chapter 1 (Warrenburg, Huron, & Way, in preparation).

Methods

Mediation Analyses

In order to determine possible mediators of the relationship between acetaminophen, familiarity, and blunted evaluation ratings, mediation analyses were conducted using the SPSS Version 25 statistical package and the PROCESS macro (Hayes, 2012). Model 4 was used to construct a 95% confidence interval using 5,000 bootstrap samples.

Variables analyzed included the evaluations (positivity ratings and negativity ratings) of the clips as well as arousal ratings, which were probed by asking participants:

> "*To what extent does this audio file sound positive?*" using an 11-point Likert scale (0: not at all positive, 10: extremely positive)

"*To what extent does this audio file sound negative?*" using an 11-point Likert scale (0: not at all negative, 10: extremely negative)

"*To what extent does this audio file sound energetic/arousing?*" using an 11-point Likert scale (0: this sound represents no energy/arousal, 10: this sound represents an extreme amount of energy/arousal).

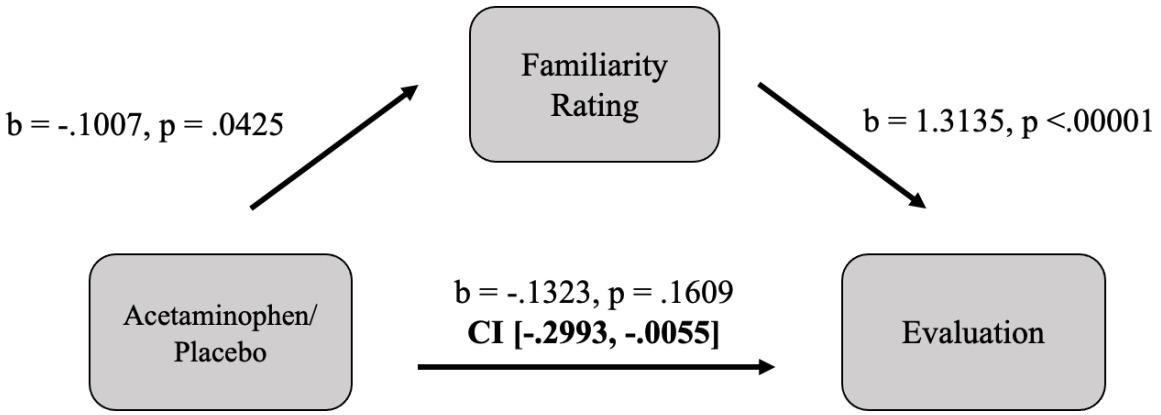
In order to integrate the separate measures of positive and negative evaluation for each music clip, the two scales were added to obtain a measure of the extremity of evaluation. This follows prior work in the lab which showed that acetaminophen reduced the extremity of evaluation (Durso et al., 2015). The extremity of evaluation variable is used in the mediation analyses below. The familiarity variable is the same as described in Chapter 1.

Results

Model 1: Familiarity as Mediator of Drug Effects on Evaluations and Emotion Ratings

Familiarity significantly mediated the relationship between drug condition and extremity ratings in positive music in the evaluations portion of the study (Figure 5), but not for negative music [-0.1711, 0.0442] or all music [-0.2493, 0.0155]. Significant mediation is shown by the c-path in which the confidence interval does not contain zero, meaning that the relationship between drug condition and extremity ratings becomes nonsignificant when controlling for familiarity, i.e., familiarity is the explanation for this relationship.

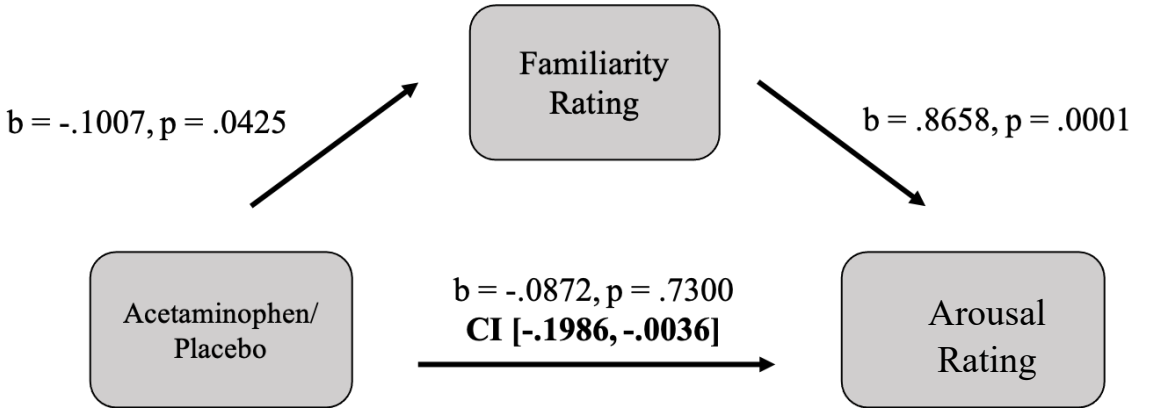
Figure 5: Familiarity Mediates Blunted Evaluations in Positive Music



There was no significant mediation by familiarity on extremity ratings in the experienced emotions block of the study for all music, [-0.2518, 0.0151], or positive [-0.2974, 0.0168] or negative music [-0.2303, 0.04171].

Familiarity also significantly mediated the relationship between drug condition and arousal ratings for the positive music clips, in the evaluations portion of the study (Figure 6). However, there was no significant mediation by familiarity on arousal ratings for the negative music clips [-0.1214, 0.0240].

Figure 6: Familiarity Mediates Blunted Arousal in Positive Music



Model 2: Evaluations and Emotion Ratings as Mediator of Drug Effects on Familiarity

Extremity ratings significantly mediated the relationship between drug condition and familiarity ratings in all music (Figure 7), as well as specifically in positive music (Figure 8) and in negative music (Figure 9), for the evaluations block of the study.

Figure 7: Evaluation Mediates Blunted Familiarity Ratings in All Music

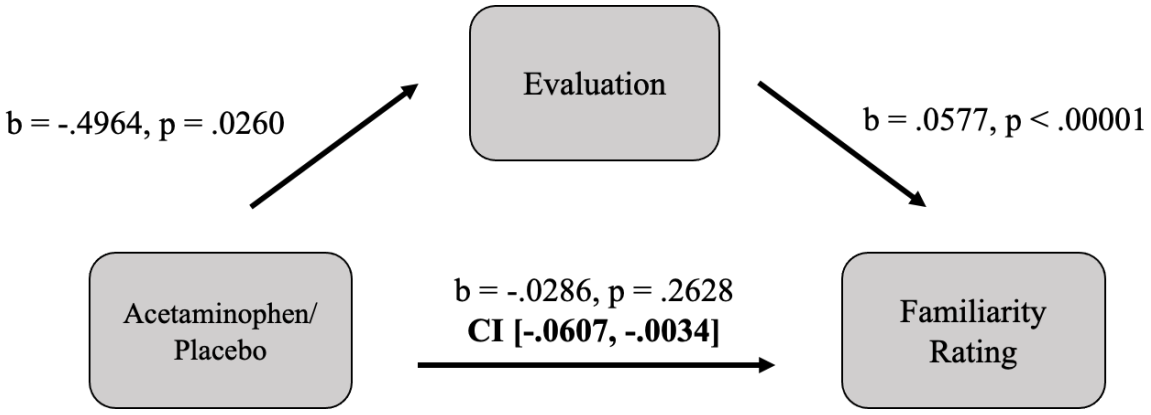


Figure 8: Evaluation Mediates Blunted Familiarity Ratings in Positive Music

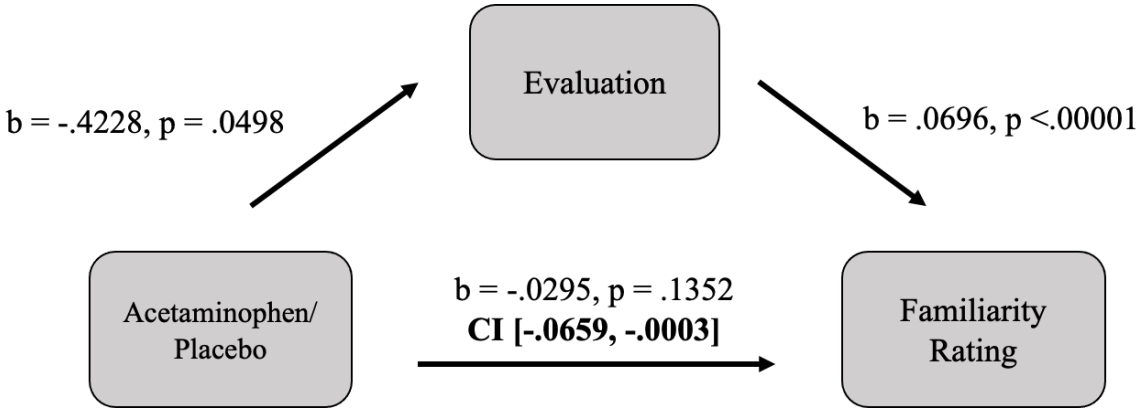
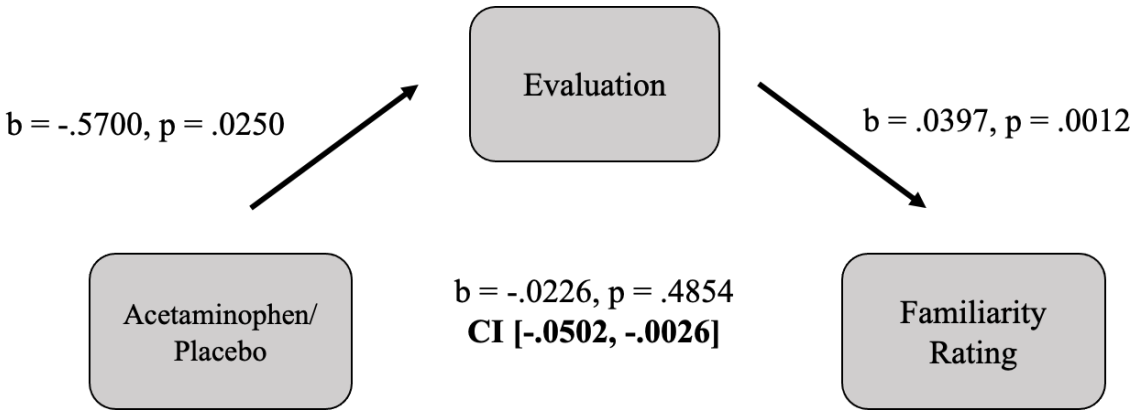


Figure 9: Evaluation Mediates Blunted Familiarity Ratings in Negative Music



There was no significant mediation by extremity ratings on familiarity ratings in the experienced emotions block of the study [-0.0199, 0.0374], which is consistent with the lack of effect of drug on experienced emotions.

Discussion

The results of these mediation analyses show a bidirectional relationship between familiarity and evaluations. Familiarity mediates blunted extremity and arousal ratings in positive music, indicating that familiarity may explain the effects seen in prior work of acetaminophen reducing extremity and emotions. However, extremity ratings also mediate familiarity ratings in all music, indicating that the prior work showing acetaminophen's reductions in extremity ratings may have been one half of the full story. Experienced emotion affected familiarity but not arousal ratings, yet in the evaluations block, evaluations were a stronger mediator than familiarity. It is unclear which model of mediation is more strongly supported, based on the current dataset (Warrenburg, Huron, & Way, in preparation). Further experimental work needs to be done in order to discriminate between these two mediation

models and examine depth of familiarity, given that overall familiarity ratings in the current dataset suggest that most participants were not familiar with the music clips.

While the present analyses support the two different mediation models for acetaminophen's extremity and familiarity blunting effects, there are some limitations. First, this study measured familiarity using a 3-point scale. Future studies should use a more precise scale in order to better examine nuances of familiarity. Perhaps with a more precise scale of familiarity as well as music clips that have higher average familiarity ratings, mediation would be stronger for one of the two proposed hypotheses. This would provide greater range and variability, which would increase sensitivity to any drug effects. In addition, in order to have a more precise measure of familiarity, future studies should manipulate familiarity by varying the number of times specific music clips are repeated. By repeating a music clip and inducing familiarity, the familiarity variable can be controlled and the extremity variable can be dependently analyzed.

Second, there were only 15 music clips played in the evaluations block of the study, the portion of the study showing significant mediation. Future studies should include more music clips in order to detect more robust and reliable effects. In addition, future work should continue to manipulate valence of the music clips played in order to control more for extremity ratings: by playing positively-valenced music clips, evaluations should be on average more positive, allowing familiarity to be analyzed dependently. The combination of controlling valence of music clips and number of times a music clip is played should allow for discrimination between the two proposed models of mediation.

In conclusion, this study adds to the literature by identifying two possible mechanisms for acetaminophen's psychological effects in altering perceptions of music clips. The results suggest that familiarity should be examined further as a possible mechanism behind these effects, in

order to determine if acetaminophen impairs familiarity ratings, or if acetaminophen impairs extremity ratings that then inhibit familiarity ratings.

CHAPTER 3

Introduction

The results from chapters 1 and 2 of this project show support for two distinct models of mediation explaining the relationships between acetaminophen, blunted familiarity, and blunted evaluations of music. The following study protocol has been designed to test one of these two proposed models: the mere exposure and processing fluency model. The study will replicate several previous procedures and extend them by exploring depth of processing as a mechanism for explaining the effects seen in prior work. It will maintain the general structure of the previous study (Warrenburg, Huron, & Way, in preparation), but will make key changes in order to home in on the familiarity component of processing.

Repetition of Music Clips to test Mere Exposure Effects

This study will feature a within-subjects manipulation of levels of familiarity via repetition of music clips. Participants will listen to and rate some music clips prior to taking the drug and some of these clips will be repeated after drug absorption. The within-subjects music clips will be chosen to have overall low familiarity ratings, in order to test effects of repetition on increasing familiarity. This will provide insights into the effect of acetaminophen on reducing mere exposure and processing fluency effects of repetition.

If the placebo group shows a higher increase in overall familiarity for the clips that are repeated, then we can conclude that acetaminophen is impairing the mere exposure and processing fluency effects. In other words, if a music clip is played once before taking the drug and once again after taking the drug, we would expect an increase in positive evaluation, given the mere exposure and processing fluency hypothesis. However, if acetaminophen is blunting familiarity, and familiarity is mediating the increase in positive evaluations, we hypothesize that

the acetaminophen participants would show less of a positive evaluation than the placebo participants.

Variability of Familiarity

In addition to adding this new task to assess mere exposure and processing fluency effects, we will also have participants do a 2nd task that is very similar to the prior study with several modifications in order to better understand the effects of acetaminophen on familiarity. One key change that this study will address is the need for a more precise measure of familiarity. This will be achieved by implementing an 11-point scale, rather than a 3-point scale. By doing so, the variability of familiarity should increase and allow for greater sensitivity in the measurement of familiarity.

Another key change that will increase sensitivity to detecting drug effects on familiarity is the selection of musical stimuli. Rather than selecting stimuli with fairly low average familiarity ratings as before, the proposed stimuli will cover a range from unfamiliar to extremely familiar. This will allow us to better distinguish the main effects of drug on familiarity. The literature suggests that the musical clips which are moderately familiar to participants will yield the largest effects on evaluations. Therefore, stimuli for this study will be selected to include a majority of moderately familiar clips. This will allow us to test for a main effect of drug on ratings of familiarity across stimuli that vary in their familiarity as well as replicate the effects of familiarity on mediating the evaluating blunting effects of acetaminophen.

Depth of Familiarity as a Moderator

Another goal of this study is to investigate the interaction between drug condition (acetaminophen vs. placebo) and familiarity. This will determine if acetaminophen universally blunts evaluations across stimuli, or if it has stronger blunting effects for moderately familiar

stimuli as compared to stimuli with low familiarity and stimuli that are recognized and have high familiarity.

For the music clips played once, some will be low in familiarity, some will be moderately familiar, and some will be highly familiar. This will allow us to analyze if the degree to which a clip is familiar impacts acetaminophen's effects. We hypothesize that familiarity will be a moderator of the relationship between acetaminophen and blunted evaluations, such that the blunting will be highest for music clips that are moderately familiar, but lower for unfamiliar and extremely familiar music clips.

The literature surrounding familiarity with the mere exposure effect, processing fluency, and warm glow heuristic are all affectively positive. Therefore, we do not expect negativity blunting by acetaminophen to be as strong as the positivity blunting. However, previous work (Durso et al., 2015) has shown blunted negative evaluations in response to visual stimuli, therefore, we expect to see an effect of acetaminophen blunting negativity ratings, to a smaller degree than the positivity blunting. We also hypothesize that familiarity will be a significant mediator of this negativity blunting: moderately familiar stimuli will lead to more positive evaluations, i.e., reduced negative evaluations. If acetaminophen is blunting familiarity, then it would in turn lessen the negativity blunting in the acetaminophen condition as compared to the placebo condition.

Recognition versus Familiarity

There is an important distinction between familiarity and recognition, which explains the lack of a positive evaluation when a stimulus can be tied to a specific memory trace. Recognition means that there is a specific episodic source memory, while familiarity is a subjective sense of knowing something without knowing the source of that knowledge (Cleary, 2008). In a study in

which stimuli were originally presented for both short and long periods of time, then shown again to participants later, the mere exposure effect only took place for those stimuli displayed for short periods of time (Phaf & Rotteveel, 2005). The reasoning for this is the distinction between recognition and familiarity: the stimuli presented for longer periods of time allowed for the formation of a memory trace. In essence, because the exposure to the stimulus was more than 'mere', the mere exposure effect was overcome, and positivity was not felt towards the longer-displayed stimuli. For the stimuli displayed for a short period of time, positivity was increased, due to the mere exposure effect.

In addition, the same distinction between recognition and familiarity is important to the warm glow effect. When something is highly familiar, heuristics generally will not be used because there is enough source knowledge, in the form of memory traces, to process the stimulus without needing to make shortcuts. Indeed, research shows that with stimuli that are recognized by participants, a warm glow effect is not observed: there are less positive evaluations to the recognized stimulus, and these evaluations do not lead to increased familiarity ratings (Monin, 2003). Therefore, the effect of warm glow heuristic is only seen with stimuli that seem moderately familiar, yet aren't tied to a specific memory trace. While the present study aims to test the mere exposure and processing fluency model, it is important to understand the relevance of recognition to both models of mediation.

Based on this research, a recognition measure will be added to this study. Participants will be asked if they are able to name the clips of music they hear and will be prompted to enter the name of the clip if they choose yes. This will allow us to distinguish between drug effects on recognition and familiarity. In other words, we will see if the ability to recognize the stimulus moderates the drug effect.

Methods

The initial application for Institutional Review Board approval of this study was submitted on November 4th, 2020, and is still pending. Therefore, the following methods are those currently proposed.

Participants

Participants in the study will be comprised of undergraduate psychology students from the Research Experience Program (REP) at The Ohio State University, as well as Amazon Mechanical Turk workers. REP participants will earn course credit for participation in the study, and Amazon Mechanical Turk workers will be paid for participation in the study (This will be the first online experimental pharmacology study we are aware of). We aim to recruit 350 participants which will provide 80% power to detect an effect size of $d = 0.3$ with an alpha of $p=0.05$.

Drug

Participants will be randomly assigned to ingest either a 1000 mg capsule of acetaminophen, or an identical 1000 mg placebo capsule. This will be a double-blinded study, parallel-arm study.

Procedure

The musical clips used in this task will be a combination of stimuli drawn from the previous study (Warrenburg, Huron, & Way, in preparation), as well as from various sources of moderately familiar music clips such as a YouTube compilation entitled “79 Instrumental songs everyone knows, but no one knows the name of (TV Show & Advertising Music)” and a blog

post entitled “20 top instrumental TV theme songs” (Mahnke, 2013; Redaktion). Some music clips will be played once, while others will be played once before the participant ingests the drug, and once while the drug is active in the participant’s bloodstream, in order to induce familiarity. The clips that are repeated will be those pre-rated as unfamiliar, while the clips that are played once will come from music sets of moderately familiar music.

Before taking the drug, participants will listen to various unfamiliar music clips ranging from 10-15 seconds and answer the following questions:

> “*To what extent does this audio file sound negative or positive?*” using an 11-point Likert scale (0: extremely negative, 10: extremely positive)
>
> “*To what extent does this audio file sound energetic/arousing?*” using an 11-point Likert scale (0: this sound represents no energy/arousal, 10: this sound represents an extreme amount of energy/arousal).
>
> “*To what extent does this audio file sound familiar?*” using a 11-point Likert scale (0: this clip is unfamiliar, 10: this clip is extremely familiar).
>
> “*Can you name this piece of music?*” with “yes” or “no” responses. If “yes” is chosen, participants will be prompted to type in the name of the piece of music.

Approximately one hour after taking the drug (in order to ensure it is active in the participant’s brain), participants will listen to various music clips, ranging from 10-15 seconds in length, and answer the same four questions. Some of the clips listened to after taking the drug will be the same ones that the participant heard before taking the drug; this allows us to manipulate familiarity. The other clips will vary in familiarity in order to examine the degree to which familiarity moderates the effects of acetaminophen on ratings of familiarity.

Once IRB approval is obtained, this study will be run to test the proposed model. Results will be reported in the future.

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